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An Economic Analysis of Agricultural Sustainability in Orissa

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Abstract

The development of a method for generating Sustainable Livelihood Security Index (SLSI) for agricultural sustainability and evaluating the existing status has been reported. Some measures have been suggested to promote sustainable agriculture of Orissa. This state has been selected since it faces wide inequality, improper management and over-exploitation of natural resources and explosion of population. These have created a threat to ecological balance and economic as well as social status of households in different districts of the state. The study of Ecological Security Index (ESI), Economic Efficiency Index (EEI) and Social Equity Index (SEI) has revealed that the agricultural systems of all districts display wide variations in their ecological and social equity aspects relative to their economic aspects. The districts with better SLSI ranks are often described as advanced districts and vice versa. Hence, SLSI has been found to reflect the picture of overall performance of a district in three dimensions of sustainability. On the basis of the overall performance of districts in terms of their SLSI, only eight districts in the state have an index value of more than 0.5, while thirteen districts have SLSI less than 0.4. Also, many districts of coastal Orissa have depicted better performance in agricultural sustainability in comparison to the districts of western Orissa as a whole. Some policy implications of SLSI approach have also been reported.

Introduction

Sustainable agriculture may be regarded as the successful management of resources for agriculture to satisfy the changing human needs while maintaining or enhancing the quality of environment and conserving natural resources (FAO, 1991). Sustainable agriculture integrates three main goals"environmental health, economic profitability, and social equity. Swaminathan (1993) has identified 14 major dimensions of sustainable agriculture covering social, economic, technological, political and environmental facets of sustainability. Success in promoting sustainable agriculture can be achieved on seven fronts, viz. Crop diversification, Genetic diversity, Integrated nutrient management (INM), Integrated pest management (IPM), Sustainable water management, Post-harvest technology and Sound extension programmes.

Agriculture is the mainstay of economy and sustenance of life of the people in the state of Orissa. It contributed about 21 per cent to NSDP for the state in 2006-07 (at 1993-94 prices) and provided employment directly or indirectly to around 65 per cent of the total work force as per the 2001 census. Orissa is endowed with maximum natural resources in India. The development of agriculture in the state has lagged behind due to constraints like practising of traditional methods of cultivation, lack of access to modern technology, low productivity, inadequate capital formation and low investment, inadequate irrigation facilities, uneconomic size of holdings,

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widespread illiteracy among farmers, helpless victims of natural calamities, inefficient management of resources, poor performance of extension education and inadequate agricultural marketing facilities. Orissa was purposively selected for the study because it faces wide inequality, improper management and over-exploitation of natural resources and explosion of population. These have created a threat to ecological balance and economic as well as social status of households in different districts of the state. The persistently increasing inequality has become a big threat to the successful development of sustainable agricultural in the state.

In the present study, a suitable method has been evolved for generating Sustainable Livelihood Security Index (SLSI) for agricultural sustainability and evaluating the existing status. Some measures have also been suggested to promote sustainable agriculture in Orissa.

Methodology

The SLSI methodology is a generalization of relative approach underlying the Human Development Index, developed by the United Nations Development Programme (UNDP, 1992). It is a cross-sectional measure to evaluate the relative sustainability status of a given set of entities. The Sustainable Livelihood Security Index (SLSI) has been proposed by Swaminathan (1991) to serve as an educational as well as policymaking tool to evaluate the potential of sustainable development (SD). The concept of Sustainable Livelihood Security (SLS), as defined by Swaminathan (1991), is 'livelihood options which are ecologically secure, economically efficient and socially equitable'. The intimate conceptual, casual and operational linkages between SLS and other welfare goals like poverty alleviation, meeting basic needs for human development and quality of life (Saleth and Swaminathan, 1993) justify SLSI as a basic requirement of sustainable development of agriculture (SDA). The analytical approach essential for operationalising SLS in the form of SLSI is identified by the following propositions of SDA. First, the three-dimensional conceptions of the SDA are: ecological security, economic efficiency and social equity in both intra and inter-regional contexts. Second, the dynamic and contextual nature of SDA, sustainability evaluation needs to be relative rather than absolute in both time and space. Lastly, in an operational context, the multidimensional conception of SDA requires the SLSI to be a composite of three indices, viz. Ecological Security Index (ESI), Economic Efficiency Index (EEI) and Social Equity Index (SEI), so that it can take stock of both the conflicts and synergies among ecological, economic and equity aspects of SDA.

Let X_{ijk} and $SLSI_{ijk}$ denote the value of the ith variable, jth component of kth district and index for the ith variable representing the jth component of the SLSI of kth district respectively. Then, we have:

$$SLSI_{ijk} = \frac{X_{ijk} - \min_k X_{ijk}}{\max_k X_{ijk} - \min_k X_{ijk}} \qquad \ldots(1)$$

$$SLSI_{ijk} = \frac{\max_k X_{ijk} - X_{ijk}}{\max_k X_{ijk} - \min_k X_{ijk}} \qquad \ldots(2)$$

where,

i = Variables (1, 2, 3, ……………….,I)

j = Components (1, 2, 3,………….., J)

k = Districts (1, 2, 3,………………, K)

Equation (1) is applicable to variables having positive implications for SLS and Equation (2) is applicable to variables having negative implications for SLS. The numerators in Equation (1) measure the extent by which the kth district did better in the ith variable representing the jth component of its SLSI as compared to the region(s) showing the worst performance. The denominator is actually the range, i.e. the difference between the maximum and minimum values of a given variable across districts, which is a simple statistical measure of total variation evinced by that variable. The denominator, in fact, serves as a scale or measuring rod by which the performance of each region is evaluated for a given variable. Such a scale can also be identified exogenously utilizing scientific standards, social norms or even policy targets.

Having calculated the $SLSI_{ijk}$ for all variables, the indices for various components of SLSI were calculated as a simple means of the indices of their respective variables, i.e.:

$$SLSI_{jk} = \frac{\sum_{i=1}^{I} SLSI_{ijk}}{I} \qquad \ldots(3)$$

where,

j = 1, 2, 3,……………….,J, and

k = 1, 2, 3,………………,K

Then, the composite indicator for each region was calculated as a weighted mean of the component indices obtained from Equation (3), i.e.

$$SLSI_{jk} = \frac{\sum_{j=1}^{j} W_{jk} SLSI_{ijk}}{J} \qquad \ldots(4)$$

The W_{jk} in Equation (4) denotes the weight assigned to the jth component of SLSI of kth region, and has the property that: W_{ik} +…………………… + W_{jk} = 1. If the weights are identical and sum up to unity, then SLSI is calculated as a simple mean. But, when the weights are different across all js and ks, then SLSI is calculated as a weighted mean. For distinction, the former has been denoted simply as 'SLSI' and the latter as 'SLSI*'.

Most of the composite indices developed to date including the PQLI, HDI and SLSI constructed by Saleth and Swaminathan (1993), are based on an unrealistic assumption of equal weights, mainly due to non-availability of suitable methodology for identifying the weights. In this section, a very simple and generalisable procedure for deriving a weighted scheme with certain desirable properties essential for constructing a more realistic weighted composite index has been outlined. Since SLSI is composite in nature and the relative significance of its components varies across districts, there is also an inherent need to develop an appropriate weighting system. While one can think of more sophisticated approach that derives weights through some sort of social welfare function or econometric techniques like factor analysis, both the conceptual and data related problems mark their practical utility and applicability. Similar is the case with the 'delphi' procedure in which the learned judgment and opinion of a panel of experts and scientists form the basis for the weighting scheme. Here, an attempt has been made to develop the weighting scheme within a linear programming context.

The weighing scheme was designed to have the following two desirable properties: (i) it assigns differential weights not only to the different components of SLSI but also across districts for any given component. It was required because the relative significance of components and variables representing them, varied across districts; and (ii) weightage assigned by the scheme to different components of the composite indicator should be inversed to their relative significance as reflected by their values. The practical rationality and need for the equalising requirement implied by the second property was demonstrated by the different components of SLSI. The second property helped in addressing as well as accommodating such a differential concern through a weighted SLSI.

The approach used to derive the weighting scheme with the above two properties can be described in a more generalized form as:

Algebraically,

$$\text{Max} \sum_{j=1}^{j} a_{jk}\ x_{jk}$$

Subjected to $\sum_{j=1}^{j} a_{jk} = 1$

where,

a_{jk} = Coefficient associated with the jth component of SLSI of district k, and

X_{jk} = Value of the jth component of SLSI of district k.

In other words, the problem specified above states that the weighted sum of the value components of SLSI is maximized such that the weights sum up to unity. Due to the very nature of the maximization problem specified above, its solution, i.e. a_{jk} (j = 1, 2, 3…….,J) will be greater than others and those X_{jk} (j = 1, 2, 3, ……,J) that have higher values than others and vice-versa. It requires instead, the a_{jk} (j = 1, 2, 3, ….,J) to assign higher weights to those X_{jk} (j = 1, 2, 3….,J) that have lower values and vice-versa. This is for two important reasons. First, taking the a_{jk} straight as weights could create a biased composite indicator that inflates the contribution of better-performing component and deflates the least-performing one, defeating the very purpose of the weighting system. This could also distort the policy formulation process where it is required to attach added emphasis to the least-performing components. Second, as it is a cross-sectional comparison at a given point of time, we need to take stock of the differential emphasis placed by different districts on different components of SLSI.

To obtain a_{jk} that will assign a higher weight to X_{jk}, that has lower value, we first take the inverse of a_{jk}, i.e. $1/a_{jk}$ and denote this ratio as r_{jk}; then the actual weight to be assigned to X_{jk}, i.e. W_{jk}, will be equal to (r_{jk} " "r_{jk}). By repeating the procedure, we could find a set of district and component-specific weights for the districts for which the SLSI was to be constructed.

The procedure of weighting can be summarized as follows: first, the inverse of the proportional contributions of ESI, EEI and SEI to SLSI is to be obtained. Then, the weights to be assigned to each component will be the ratio of its inverse contribution to the sum of all the three inverse proportions.

Selection of Variables for Agricultural Sustainability

For any study on sustainable agriculture, the assessment of agricultural sustainability is a big question. To empirically estimate SLSI, a simple approach was followed involving the selection of a set of variables or indicators having the ability to say something more relevant and substantial about the ecological, economic and equity aspects of sustainable development of agriculture (SDA). Although many indicators have been developed, they do not cover all the aspects of sustainability. Moreover, due to variations in biophysical and socio-economic conditions, indicators used in one region are not necessarily applicable to the other regions. For instance, twelve variables have been selected to illustrate the three dimensions of SDA.

Ecological security is assessed based on four variables, viz. Population density (per km^2), Proportion of geographical area under forest (%), Cropping intensity (%) and Livestock density (per km^2). Effective utilization of human resources and improvement in the overall quality of life of households are important for the sustainable development. If the people are healthy, educated and adequately skilled, they can participate fully and contribute more to the economic development process. Human resources hold the key to breaking the stagnation in agricultural growth and productivity. Thus, the variable population density was selected in view of its capacity to reflect the extent of human pressure on the overall ecological security. Forests play a vital role in maintaining ecological balance and contribute significantly to the state economy. Forest activities contribute significantly to the food security and livelihood of people living around forests. Since forest occurrence and growth is governed by regional-specific geophysical conditions, the critical minimum forest cover essential for ensuring the ecological security does vary across regions. For instance, the respective critical minimum forest cover norms suggested by FAO for the plains, plateau and hills and mountainous regions are: 20 per cent, 33.3 per cent and 66.6 per cent, respectively. To achieve 33 per cent forest cover as recommended in the National Forest Policy, 1988, afforestation of wastelands and rejuvenation of degraded forests are being accelerated. Hence, the variable forest cover was selected for ensuring ecological security.

Cropping intensity is one of the indices of the level of SDA. It measures the extent of land-use for cropping purposes during a given year. Due to development of irrigation facilities, more areas have been brought under cultivation and farming communities could raise more than one crop on the same land in the same year. With a view to assess agricultural sustainability in the context of ecological security, cropping intensity variable has a significant contribution. Livestock sector plays an important role in the socio-economic development of a nation by contributing significantly to not only value-added products in agriculture and allied sector but also providing employments, incomes and nutritional security to both urban and rural households. Thus, livestock density was selected in view of its capacity to reflect the extent of animal pressure on the overall resources of environment.

Economic efficiency is reflected by the four variables: yield rate of rice (q/ha), per capita output of foodgrains (kg/annum), fertilizer consumption (kg/ha), and per capita income (Rs). Rice being the main staple food, is cultivated widely in Orissa. It covers around 76 per cent of the total gross cropped area. Yield rate of rice is influenced directly or indirectly to the soil fertility, climate, irrigation, technologies and market performance. However, it has the potential to bias the evaluation in favour high-value cash crops of the districts. So the variable yield rate of rice was selected to assess the economic efficiency for agricultural sustainability. According to FAO (1997), food security at the household level is the ability of households to meet their daily food needs from their own production, or from off-farm sources. The variable per capita output of foodgrain has the potential to food security status when it is contrasted with the critical minimum per capita grain availability i.e.180 kg/capita/ annum, suggested by Brown (1987). Food security is one of the most important concerns in Orissa because of limited land for agricultural use and ever-increasing population. Optimum use of fertilizer at the opportune time is an essential ingredient for increasing agricultural productivity. It also protects land fertility by meeting the nutrition requirement of crops. Thus, the variable fertilizer consumption plays a crucial role in agricultural sustainability. Per capita income has a vital role in the process of national development. It also reflects the picture of the overall standard of living, economic strength and prosperity. So the selected variable per capita income has a good capacity to represent economic efficiency for agricultural sustainability.

Social equity is represented by the following four variables: Female literacy (%), Infant mortality rate, Rural road connectivity (km) and Villages electrified (%). Female literacy rate plays a vital role in the process of women empowerment and national development. It shows the potential not only for women's social and economic participation but for population stabilization also. So, the selected variable 'female literacy' is capturing social equity for agricultural sustainability. The chosen variable 'infant mortality rate' reflects the picture of health awareness and availability of facilities in the society. 'Rural road connectivity' is a crucial element of rural infrastructure scenario. Poor road connectivity is the important facet of backwardness of the region. Overall, it is a significant step to address the important issue of rural infrastructure required for economic growth. Village electrification scenario in the state continues to be a matter of concern. Lack of reliable electricity supply dampens the growth impulses in different sectors of the economy. It is an essential pre-requisite of social equity for achieving overall sustainable agricultural development.

Despite variations and limitations, the selected variables do have a good capacity to reflect the picture of overall ecological, economic and equity aspects of a district's agricultural systems. The secondary sources of data and general information for the twelve potential variables for all the districts of Orissa were obtained from Directorate of Economics and Statistics, Orissa, Bhubaneswar (2005-06) and Orissa Human Development Report (2004).

Results and Discussion

The study revealed that the values of sustainability status ranged from 0.14 to 0.68 for ESI, 0.07 to 0.75 for EEI and 0.21 to 0.70 for SEI. This shows that the agricultural systems of all the districts in Orissa display wide variations in their ecological, economic efficiency and social equity aspects. The SLSI indicated a range from 0.18 to 0.59 and SLSI* reflected a range from 0.21 to 0.62. The results indicated that there was a significant variation between SLSI and SLSI* values. The SLSI* ranking of various districts differed significantly from their SLSI ranking. As a result, the effect of the weightaging procedure of SLSI* range deflated a slightly better performance but inflated the poor performance substantially. Such an equalizing or normalizing effect is favourable for districts with poor performance as inter-districts priority for investment in allocation of resources will be inversed to their ranking. The relatively narrower range of SLSI and SLSI* as compared to their component indices described that the performance of districts was not consistent across the three aspects (ESI, EEI and SEI) of sustainable development of agriculture (SDA).

Table 1. Ecological , economic and equity variables selected for agricultural sustainability in Orissa

Sl No.	Districts	Ecology				Economic				Social equity			
		Population density/km^2	Forest cover (%)	Cropping intensity (%)	Livestock density/ km^2	Yield rate of rice (q/ha)	Fertilizer consum-ption (kg/ha)	Per capita output of foodgrain (kg/annum)	Percapita income (Rs)	Female literacy (%)	Infant mortality rate	Rural road (km)	Villages electrified (%)
1	Angul	179	43.6	175	195	3.9	23	51	10877	55.4	95	687	80.3
2	Balasore	532	9.1	141	638	9.5	106	189	3961	58.9	101	1221	93.5
3	Bargarh	231	20.9	134	206	12.7	95	271	4765	50.3	100	1112	98.9
4	Bhadrak	532	3.7	140	470	12.5	98	191	3916	62.8	65	863	83.8
5	Bolangir	203	23.4	135	281	2.9	25	71	4538	39.5	97	1228	94.1
6	Baudh	121	37.1	155	194	4.5	27	107	4436	39.0	104	502	60.8
7	Cuttack	595	21.2	190	388	11.5	43	85	6116	66.9	63	1275	98.6
8	Deogarh	93	56.1	162	155	4.3	26	82	5022	47.2	49	663	46.6
9	Dhenkanal	240	37.8	162	271	4.8	21	75	5046	57.9	97	805	93.9
10	Gajapati	120	64.1	184	179	10.1	35	157	5498	28.4	143	479	50.4
11	Ganjam	385	36.2	168	340	8.6	52	115	5013	46.4	107	2338	86.8
12	Jagatsingpur	634	6.6	190	445	11.7	35	124	5340	69.3	125	807	96.5
13	Jajpur	560	24.9	175	519	7.4	42	74	4468	60.7	118	970	96.0
14	Jharsuguda	245	9.1	132	194	6.9	73	49	11210	58.5	71	479	99.7
15	Kalahandi	169	37.5	149	219	4.4	46	276	4043	29.3	51	1061	63.6
16	Kandhamal	81	74.6	156	142	7.8	3	84	4743	35.8	169	775	49.1
17	Kendrapada	492	9.8	185	298	9.2	26	108	3964	66.7	77	744	91.5
18	Keonjhar	188	37.3	148	294	5.1	28	147	5286	46.2	117	1229	85.5
19	Khurda	667	21.4	158	660	4.6	41	99	7353	70.4	57	923	94.1
20	Koraput	134	23.8	133	194	10.4	21	226	5148	24.2	136	778	53.0
21	Malkangiri	87	54.1	165	228	5.9	24	147	4436	20.9	151	824	41.8
22	Mayurbhanj	213	42.1	124	378	8.1	35	183	4297	37.8	48	2466	67.7
23	Nabarangpur	194	46.5	144	264	5.4	46	220	3787	20.6	117	1019	76.8
24	Nayagarh	222	49.0	155	164	6.2	25	138	4236	57.6	98	545	73.6
25	Nuapada	138	36.6	152	153	2.6	22	69	4018	25.8	62	262	80.9
26	Puri	432	4.6	196	273	8.8	56	121	4933	67.6	73	796	97.9
27	Rayagada	118	37.1	157	172	8.5	33	124	5300	24.5	131	931	39.5
28	Sambalpur	141	54.1	151	148	11.2	78	109	6171	55.1	102	904	72.0
29	Sonepur	232	17.5	163	241	10.4	27	253	4353	46.2	96	385	88.6
30	Sundargarh	188	51.1	124	280	3.3	21	75	6823	53.9	62	1294	89.8
	Orissa	236	37.3	152	269	7.6	43	134	5264	50.5	97	28365	77.0

Source: Directorate of Economics and Statistics, Orissa, Bhubaneswar (2005-06), *Orissa Human Development Report* (2004)

Table 2. Individual indices to capture the ecological, economic and equity indices for agricultural sustainability in Orissa

Sl No.	Districts	Ecology Security Index (ESI)				Economic Efficiency Index (EEI)				Social Equity Index (SEI)			
		Population density index	Forest cover index	Cropping intensity index	Livestock density index	Rice yield index	Food security index	Fertilizer consumption index	Income index	Female literacy index	Infant mortality index	Rural road index	Villages electrified indexz
1	Angul	0.17	0.56	0.71	0.10	0.13	0.01	0.19	0.95	0.70	0.39	0.19	0.68
2	Balasore	0.70	0.07	0.23	0.96	0.68	0.61	1.00	0.02	0.77	0.44	0.43	0.90
3	Bargarh	0.25	0.24	0.14	0.12	1.00	0.98	0.89	0.13	0.59	0.43	0.38	0.98
4	Bhadrak	0.76	0.00	0.22	0.63	0.98	0.62	0.92	0.02	0.85	0.14	0.27	0.73
5	Bolangir	0.21	0.28	0.15	0.27	0.03	0.09	0.21	0.10	0.38	0.40	0.44	0.90
6	Baudh	0.07	0.47	0.43	0.10	0.19	0.25	0.23	0.08	0.37	0.46	0.11	0.35
7	Cuttack	0.87	0.24	0.91	0.47	0.88	0.16	0.39	0.31	0.93	0.12	0.46	0.98
8	Deogarh	0.02	0.74	0.53	0.02	0.17	0.14	0.22	0.16	0.53	0.01	0.18	0.12
9	Dhenkanal	0.27	0.48	0.52	0.25	0.22	0.11	0.17	0.17	0.75	0.40	0.25	0.90
10	Gajapati	0.06	0.85	0.83	0.07	0.74	0.47	0.31	0.23	0.15	0.78	0.10	0.18
11	Ganjam	0.52	0.45	0.61	0.38	0.60	0.29	0.47	0.16	0.52	0.49	0.94	0.78
12	Jagatsingpur	0.94	0.04	0.91	0.58	0.90	0.33	0.31	0.21	0.98	0.63	0.25	0.94
13	Jajpur	0.82	0.30	0.71	0.73	0.47	0.11	0.38	0.09	0.81	0.58	0.32	0.95
14	Jharsuguda	0.28	0.07	0.11	0.10	0.42	0.00	0.68	1.00	0.76	0.19	0.09	1.00
15	Kalahandi	0.15	0.47	0.35	0.15	0.17	1.00	0.42	0.03	0.17	0.02	0.36	0.40
16	Kandhamal	0.00	1.00	0.44	0.00	0.51	0.15	0.00	0.13	0.30	1.00	0.23	0.16
17	Kendrapada	0.70	0.08	0.84	0.30	0.65	0.26	0.22	0.02	0.93	0.24	0.22	0.86
18	Keonjhar	0.18	0.47	0.33	0.29	0.25	0.43	0.24	0.20	0.51	0.57	0.44	0.76
19	Khurda	1.00	0.25	0.47	1.00	0.20	0.22	0.37	0.48	1.00	0.07	0.30	0.91
20	Koraput	0.09	0.28	0.12	0.10	0.77	0.78	0.17	0.18	0.07	0.73	0.23	0.22
21	Malkangiri	0.01	0.71	0.57	0.16	0.33	0.43	0.20	0.09	0.01	0.85	0.25	0.04
22	Mayurbhanj	0.22	0.54	0.00	0.45	0.55	0.59	0.31	0.07	0.34	0.00	1.00	0.47
23	Nabarangpur	0.19	0.60	0.28	0.23	0.28	0.75	0.42	0.00	0.00	0.57	0.34	0.62
24	Nayagarh	0.24	0.64	0.43	0.04	0.35	0.39	0.21	0.06	0.74	0.41	0.13	0.56
25	Nuapada	0.09	0.46	0.39	0.02	0.00	0.09	0.18	0.03	0.10	0.11	0.00	0.69
26	Puri	0.59	0.01	1.00	0.25	0.61	0.32	0.51	0.15	0.94	0.21	0.24	0.97
27	Rayagada	0.06	0.47	0.46	0.06	0.59	0.33	0.29	0.20	0.08	0.68	0.30	0.00
28	Sambalpur	0.10	0.71	0.37	0.01	0.85	0.26	0.73	0.32	0.69	0.45	0.29	0.54
29	Sonepur	0.25	0.19	0.54	0.19	0.77	0.90	0.23	0.07	0.51	0.39	0.05	0.81
30	Sundargarh	0.18	0.67	0.00	0.26	0.06	0.11	0.17	0.41	0.67	0.11	0.47	0.83

Table 3. Relative agricultural sustainability status of Orissa

Sl No.	Districts	Ecologicalsecurity status		Economic efficiencystatus		Social equitystatus		Sustainable livelihood security status			
		Ecological Security Index (ESI)	Ranks	Economic Efficiency Index (EEI)	Ranks	Social Equity Index (SEI)	Ranks	Sustainable Livelihood Security Index (SLSI)	Ranks	Relative Sustainable Livelihood Security Index (SLSI*)	Ranks
1	Angul	0.38	11	0.32	17	0.49	17	0.39	14	0.41	17
2	Balasore	0.51	5	0.58	3	0.63	4	0.57	2	0.58	4
3	Bargarh	0.19	28	0.75	1	0.59	6	0.51	8	0.62	1
4	Bhadrak	0.41	10	0.64	2	0.49	15	0.51	7	0.53	8
5	Bolangir	0.23	27	0.11	29	0.53	12	0.29	27	0.40	18
6	Baudh	0.27	24	0.19	25	0.32	23	0.26	28	0.27	28
7	Cuttack	0.63	3	0.43	10	0.62	5	0.56	3	0.57	5
8	Deogarh	0.33	16	0.18	27	0.21	30	0.24	29	0.25	29
9	Dhenkanal	0.38	12	0.17	28	0.58	8	0.37	18	0.44	13
10	Gajapati	0.45	9	0.44	8	0.30	25	0.40	13	0.41	16
11	Ganjam	0.49	6	0.38	13	0.68	2	0.52	6	0.55	7
12	Jagatsingpur	0.62	4	0.44	9	0.70	1	0.59	1	0.60	2
13	Jajpur	0.64	2	0.26	22	0.66	3	0.52	5	0.59	3
14	Jharsuguda	0.14	30	0.53	5	0.51	14	0.39	15	0.47	11
15	Kalahandi	0.28	22	0.41	11	0.24	28	0.31	24	0.32	25
16	Kandhamal	0.36	14	0.19	24	0.42	21	0.33	22	0.35	24
17	Kendrapada	0.48	7	0.29	19	0.56	11	0.45	10	0.47	10
18	Keonjhar	0.32	18	0.28	20	0.57	9	0.39	16	0.43	14
19	Khurda	0.68	1	0.32	18	0.56	10	0.52	4	0.57	6
20	Koraput	0.15	29	0.48	7	0.31	24	0.31	23	0.37	22
21	Malkangiri	0.36	13	0.26	21	0.28	26	0.30	25	0.31	26
22	Mayurbhanj	0.31	19	0.38	14	0.45	19	0.38	17	0.38	20
23	Nabarangpur	0.32	17	0.36	15	0.38	22	0.36	19	0.36	23
24	Nayagarh	0.34	15	0.25	23	0.46	18	0.35	20	0.37	21
25	Nuapada	0.24	26	0.07	30	0.27	29	0.18	30	0.21	30
26	Puri	0.46	8	0.39	12	0.59	7	0.48	9	0.49	9
27	Rayagada	0.26	25	0.35	16	0.26	27	0.29	26	0.30	27
28	Sambalpur	0.30	20	0.54	4	0.49	16	0.44	11	0.46	12
29	Sonepur	0.29	21	0.49	6	0.44	20	0.41	12	0.43	15
30	Sundergarh	0.28	23	0.19	26	0.52	13	0.34	21	0.39	19

The SLSI* ranking implied that the districts having the best conditions for sustainable development of agriculture were Baragarh, followed by Jagatsinghpur and Jajpur. Similarly, the districts having the least desirable conditions for SDA were Nuapada, followed by Deogarh and Boudh. The SLSI* ranking appeared to effectively identify the advanced and backward districts. It was observed that districts with better SLSI* ranks were often described as advanced districts using other ecological, economic and social indicators. On the other hand, the districts with the lower SLSI ranks were generally known as backward districts, i.e. districts with poor conditions for sustainable development of agriculture during the reference period.

Hence, SLSI* reflected the picture of overall performance of a district, its component indices indicated how the districts fared in the three dimensions of sustainability. It was noted that Baragarh district had the highest SLSI*, but in terms of comparison of three indices, its performance of ecological security index was not so good as its economic efficiency and social equity. On the other hand, in the case of simple SLSI ranks, Jagatsinghpur district had the top position, followed by Balasore and Cuttack districts.

In the context of inter-district comparison of component indices (ESI, EEI, SEI), Khurda district dominated in ecological security in the coastal Orissa, followed by Jajpur and Cuttack, while most of the districts of western Orissa had poor performance in ecological security. The worst performing districts in ecological security were Jharsuguda, followed by Koraput and Baragarh. The better performing districts in economic efficiency were Baragarh, followed by Bhadrak and Balasore. Similarly, bottom list districts in economic efficiency were Nuapada, Bolangir, Dhenkanal, Deogarh and Sundargarh. In the case of social equity aspects, the districts which performed better were Jagatsinghpur, Ganjam, Jajpur, Balasore and Cuttack. On the other hand, the districts which performed worst in social equity were Deogarh, Nuapada and Kalahandi. Other worst performing districts were Rayagarda, Malkangiri and Gajapati. Thus, the districts of coastal plain of Orissa had a better performance in social equity as compared with the western part of Orissa.

Consequently, the overall performance of the districts in terms of their SLSI and SLSI* revealed that only eight districts out of 30 districts in Orissa (about $1/4^{th}$) had an index of SLSI above 0.5, while thirteen districts had SLSI* value lower than 0.4. Moreover, many districts in coastal Orissa had shown better performance in agricultural sustainability in comparison to the districts of western Orissa as a whole. Similar findings have been reported by Bharati and Sen (1997) that in the overall performance of several districts of Bihar in terms of their Relative Sustainable Livelihood Security Index (SLSI*), only about one-fourth of the 40 districts had SLSI* of above 0.5 and about half of the total districts had SLSI lower than 0.4. Thus, most of the districts of south Bihar had a better agricultural sustainability in comparison to the districts of north Bihar, in general.

Policy Implications

- The future challenges and policy implications of SLSI* approach have received increasing attention due to the fact that it helps in establishing inter-districts priorities for the allocation of agricultural resources and prioritizes the activities and programmes relevant to each district for sustainable agricultural development. The districts with an SLSI* of less than 0.4 (poor conditions for SDA) should be accorded high priority in agricultural investment.
- It the ESI of a given district has a lower value than those of other two indices, then projects focused on afforestation, agro-forestry, cultivated area and productivity enhancement, and livestock development should be accorded higher priority over the economic and social orientation programme. If SEI of a certain district has a lower value as compared to ESI and EEI values, attention towards equity enhancing for better education, health facilities, sanitary living environment, and rural infrastructure for both road connectivity and electrification should be given a higher priority.
- For evolving a sustainable agricultural system, appropriate use of local resources and better management of the environment should be implemented. As a result, these experiences build

on people's own knowledge, skill and their values, resources, culture and institutions and lead to the empowerment of farming communities.

- The policy of SDA will influence producers, consumers, agribusiness people, traders, academicians, researchers, policymakers, input suppliers, food processors and others for the successful management of natural resources, biodiversity, food and nutritional security, ecosystem services and many other challenges on the way of supporting people living in rural areas of the state Orissa.
- The development and use of micro-indicators appropriate to the Orissa agricultural situation should be encouraged.

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References

Bharti, D. K. and Sen, C. (1997) Agricultural sustainability in Bihar : An evaluation of relative status of different districts, *Journal of Agricultural Development and Policy*, **9** (2):1-13.

Brown, L. R. (1981) Building a sustainable society (New York: w.w.Norton)

FAO (1991) Sustainable agriculture and rural development in Asia and Pacific, Regional Document No. 2, *FAO/ Netherlands Conference on Agriculture and the Environment*, Hertogenbosch, The Netherlands, 15-19 April.

FAO (1997) *Implications of Economic Policy for Food Security*, Training material for agricultural planning, 40, Rome.

Government of Orissa (2004) *Orissa Human Development Report*, Planning Commission, New Delhi.

Government of Orissa (2005) *Statistical Abstract of Orissa*, Directorate of Economics and Statistics, Bhubaneswar.

Saleth, R.M. (1993) *Developing Indicators of Sustainable Development at the Global Level : Approach, Framework and Empirical Illustrations*, Institute of Economic Growth, Delhi.

Saleth, R.M. and Swaminathan, M. S. (1993) Sustainable livelihood security at the household level : Concept and evaluation methodology, In: *Proceedings of an Interdisciplinary Dialogue on Ecotechnology and Rural Employment*, Chennai,12-15 April. pp.105-122.

Swaminathan, M. S. (1991) *From Stockholm to Rio de Janeiro : The Road to Sustainable Agriculture*, Monograph No. 4, M. S. Swaminathan Research Foundation, Chennai, India.

UNDP (1992) *Human Development Report 1992*, New York: Oxford University Press.